UNITED STATES PATENT APPLICATION

FOR

TRANSPORT OF IN-BAND SIGNALING WITH REDUCED OVERHEAD ON DIGITAL SUBSCRIBER LINE TRANSCEIVERS

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FIELD

[0001] The invention relates to Digital Subscriber Line (DSL) communications. More specifically, the invention relates to techniques for transporting in-band signaling with reduced overhead using DSL transceivers.

BACKGROUND

[0002] Typical telephone lines transmit data at a rate of 64 kbit/sec, which is sufficient to provide high quality voice communications. These same lines are used to transmit data from computer systems or other electronic devices at rates up to 56 kbit/sec. Additional bandwidth can be provided by aggregating multiple channels between network nodes. This bandwidth can be provided according to multiple strategies including dynamically allotting channels as requested by a network node.

[0003] In current Digital Subscriber Line (DSL) architectures, a single voice call may be transmitted digitally using a 64 kbit/sec channel in the DSL data stream. A 64 kbit/sec channel is consumed by a telephone whether or not the phone is in use. This is because signaling bits are required to signal the state of the line. When a telephone is in use, or "off the hook," one or more bits in the data stream can be "robbed" and used to signal the state of the line. However, when the telephone is not in use, or "on the hook," these signaling bits are still required to signal the state of the line. Current DSL architectures use the full 64 kbit/sec for state of line signaling. However, because 64 kbit/sec is not required to signal the state of the line, current DSL architectures are inefficient. In general, only 8 kbit/sec is required to support state of line signaling. Therefore, 56

kbit/sec may be consumed, but unused when a telephone is on the hook and data transfer is occurring.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings in which like reference numerals refer to similar elements.

Figure 1 is a block diagram of one embodiment of a system for providing voice and data support via digital subscriber lines.

Figure 2a illustrates a DSL data stream carrying interleaved voice signals and data signals where the 64 kbits/sec used by the voice channel is fixed .

Figure 2b illustrates a data stream carrying interleaved voice signals and data signals is variable based on bandwidth provided to the voice signals.

Figure 3a illustrates one embodiment of components for transmitting a data stream carrying interleaved voice signals and data signals is variable based on bandwidth provided to the voice signals.

Figure 3b illustrates one embodiment of components for receiving a data stream carrying interleaved voice signals and data signals is variable based on bandwidth provided to the voice signals.

DETAILED DESCRIPTION

[0004] Techniques for transporting in-band signaling with reduced overhead using DSL transceivers are described. In the following description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the invention. It will be apparent, however, to one skilled in the art that the invention can be practiced without these specific details. In other instances, structures and devices are shown in block diagram form in order to avoid obscuring the invention.

[0005] Reference in the specification to "one embodiment" or "an embodiment" means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the invention. The appearances of the phrase "in one embodiment" in various places in the specification are not necessarily all referring to the same embodiment.

[0006] Within the United States, telephony signaling is transported in-band to the telephony voice sample by "robbing" single bit locations within the stream. When transporting such digital signals transparently over digital subscriber line (DSL) channels, the signaling bits require the 64 kbit/sec channel be open while no call is connected in order to signal the line state. Described herein is a framer and a technique that allows a reduced number of bits to pass through the DSL link while in the on-hook condition in order to signal the line state without wasting DSL bandwidth.

[0007] **Figure 1** is a block diagram of one embodiment of a system for providing voice and data support via digital subscriber lines. Telecommunications carriers transmit signals over trunk lines 100, which can be, for example, T1 lines, T3 lines, or any other

type of transmission medium known in the art. Trunk lines 100 carry signals between class 5 switch 110 and other switches (not shown in Figure 1). Class 5 switches provide switching between trunk lines 110 and line cards, for example, line cards 120 and 125 and other devices, for example, voice gateway 150.

[0008] Line cards 120 and 125 provide an interface between class 5 switch 110 and analog lines 130 and 135, respectively. Analog lines 130 and 135 are traditional telephone lines (e.g., twisted pair), which are known in the art. Analog lines 130 and 135 connect telephones 140 and 145 to line cards 120 and 125, respectively. The interconnection of class 5 switch 110, lines cards 120 and 125, analog lines 130 and 135, and telephones 140 and 145 represent traditional telephone communication using SS-7 signaling.

[0009] Common Channel Signaling System No. 7 (SS-7) is a global standard for telecommunications defined by the International Telecommunications Union (ITU-T) recommendation Q.700 to define procedures and protocols by which network elements of public switched telephone networks (PSTNs) exchange information to provide call setup, routing and control.

[0010] Class 5 switch 110 is coupled to voice gateway 150. In one embodiment, voice gateway 150 includes framer circuits (not shown in Figure 1) that allow the DSL data streams to carry interleaved voice signals and data signals where the interleaving is variable. Voice gateway 150 can optionally be coupled to network 153 and/or data store 157, for example, to receive instructions or for control purposes.

[0011] Voice gateway 150 is coupled to digital subscriber line access multiplexor (DSLAM) 155. DSLAM 155 separates the voice frequency signals from high-speed data

traffic and controls and routes DSL traffic between end user equipment (e.g., router, modem, network interface card) and voice gateway 150. DSLAM 155 receives signals from voice gateway 150 and routes them to the appropriate subscriber location via DSL links (e.g., 180, 185). Similarly, DSLAM 155 receives signals via DSL links and routes the signals to voice gateway 150.

[0012] In general, class 5 switch 110, voice gateway 130 and DSLAM 155 are typically located in a central office controlled by a service provider. Analog lines 130 and 135 and DSL links 180 and 185 allow communication between the service provider and various subscribers. Typically, DSL subscribers must be within a predetermined physical radius from the central office while analog subscribers can be located at any physical distance from the central office.

[0013] DSL links 180 and 185 provide a communications path between the service provider central office and subscriber locations. Subscribers have one or more DSL modems that provide an interface between DSL links and the individual devices that communicate via the DSL links. Figure 1 illustrates two DSL modems; however, any number of DSL modems can be coupled to a DSLAM.

[0014] DSL modem 160 is coupled to DSL link 180 and includes line card 190. Line card 190 provides an analog telephone interface between DSL modem 160 and telephone 143. Computer system(s) 170 is/are coupled to DSL modem 160, which provides a data path between one or more computer systems and DSLAM 155. Similarly, DSL modem 165 is coupled to DSL link 185 and includes line card 195, which provides an interface between DSL modem 165 and telephone 148. Computer system(s) 175 is/are coupled to

DSL modem 165, which provides a data path between one or more computer systems and DSLAM 155.

[0015] In one embodiment, when telephone 148 is off the hook, or in use, DSL modem 165 allots telephone 148 a 64 kbit/sec channels for communications purposes. The 64 kbit/sec channel is used for voice communication as well as state of line signaling in an any manner known in the art. DSL modem 165 allots the remaining available bandwidth to computer system(s) 175.

[0016] When telephone 148 is on the hook, or not in use, DSL modem 165 allots telephone 148 less than 64 kbits/sec for state of line signaling purposes. In one embodiment, DSL modem 165 allots telephone 148 eight kbits/sec for state of line signaling purposes; however, the bandwidth used for state of line signaling purposes can be less than or greater than eight kbits/sec. DSL modem 160 can operate in a manner similar to that of DSL modem 165.

[0017] **Figure 2a** illustrates a data stream carrying interleaved voice signals and data signals is fixed . Data stream 300 as illustrated in Figure 2a includes N bits of data information interleaved with 8 bits of voice information. The specific value of N is dependent upon the total bandwidth provided by a DSL link and can be fixed or variable. The 8-bit blocks of voice information are transmitted at a frequency of 8 kHz to provide a 64 kbit/sec channel to carry a telephone connection. In an alternate embodiment, voice signals can be communicated using channels providing different bandwidth.

[0018] **Figure 2b** illustrates two data streams one for an on-hook condition and one for an off-hook condition. Data stream 210 is similar to data stream 200 of Figure 2a in that a 64 kbit/sec voice channel is provided. The 64 kbit/sec is used for voice signaling

when the telephone is in the off-hook condition. Data stream 210 supports interleaved voice and data signaling.

[0019] Data stream 220 is used when the telephone is in the on-hook condition. In one embodiment, data stream 220 includes a one-bit 8 kHz, or 8 kbit/sec, signal to support state of line signaling when the telephone is in the on-hook condition. In alternate embodiments, a different bandwidth (e.g., 16 kbit/sec) could be used during on-hook conditions. The 8 kbit/sec channel is used to perform signaling operations such as, for example, ringing, busy signals, etc.

[0020] **Figure 3a** illustrates one embodiment of components for transmitting a data stream carrying interleaved voice signals and data signals is variable based on bandwidth provided to the voice signals. Telephone 300 is coupled to framer 320. In one embodiment, framer 320 is a part of DLAM 340, which includes other components not illustrated in Figure 3a. In alternate embodiments, framer 320 can be separate from or independent of DSLAM 340.

[0021] Telephone 300 is coupled to control circuit 310 to communicate whether telephone 300 is in the on-hook or off-hook condition. Control circuit 310 sends control signals to multiplexor 330 and multiplexor 335 to select the signals that are to be passed to DSL link 350. In one embodiment, multiplexor 330 receives an 8-bit signal from telephone 300 (via an analog to digital converter, not shown). The 8-bit signal can be transmitted in a parallel or in a serial manner. Multiplexor 330 selects between passing the full 8-bit voice signal and passing a 1-bit signal for state of line signaling.

[0022] Multiplexor 335 receives the output of multiplexor 330 and data signals from other sources, for example, computer systems. When multiplexor 330 is passing a 1-bit

signal, multiplexor 335 can pass additional bits of data signal to provide additional bandwidth to devices (not shown in Figure 3a) other than telephone 300. Thus, when multiplexor 330 is passing only line state signals from telephone, the 56 kbit/sec of bandwidth that otherwise would have been unused is filled with data from devices other than telephone 300.

[0023] **Figure 3b** illustrates one embodiment of components for receiving a data stream carrying interleaved voice signals and data signals is variable based on bandwidth provided to the voice signals. Telephone 300 is coupled to framer 370. In one embodiment, framer 370 is a part of DLAM 340, which includes other components not illustrated in Figure 3b. In alternate embodiments, framer 370 can be separate from or independent of DSLAM 340.

[0024] Control circuit 310 sends control signals to demultiplexor 380 and demultiplexor 390 to select the signals that are to be passed from DSL link 350. In one embodiment, demultiplexor 380 passes an 8-bit signal to telephone 300 (via a digital to analog converter, not shown) when telephone 300 is in the off-hook condition. Demultiplexor 390 selects between passing the full 8-bit voice signal and passing a 1-bit signal for state of line signaling.

[0025] The framer circuits are described in terms of operation on the subscriber side of DSL links. However, corresponding framer circuits are also coupled to the provider side of the DSL links. The provider side framers route state of line signaling bits and voice signal bits to the appropriate devices on the service provider side. In one embodiment, a control circuit on the provider side of the DSL link snoops the state of line

signals to determined whether the associated telephone is in the on-hook or off-hook condition.

[0026] In the foregoing specification, the invention has been described with reference to specific embodiments thereof. It will, however, be evident that various modifications and changes can be made thereto without departing from the broader spirit and scope of the invention. The specification and drawings are, accordingly, to be regarded in an illustrative rather than a restrictive sense.